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THE COST OF DISPERSED FLOC NITRIFICATION AND DENTRIFICATION FOR REMOVAL OF NITROGEN FROM WASTEWATER

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Cincinnati, Ohio

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ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Monitoring
Advanced Waste Treatment Research Laboratory
Cincinnati, Ohio

November 1970

Cost Estimates for Nitrification and Denitrification

Cost estimates have been made for nitrogen removal by means of nitrification and denitrification using two dispersed growth reactors in series. Preliminary cost data developed by Black and Veatch, under the terms of the FWQA contract, were used as a basis for the cost estimate.

The nitrification process is essentially identical with the activated sludge process. Three hours detention time in the aerator was provided with the excess capacity of 1.2. A final settler was sized using an overflow rate of 800 gpd/sq. ft. based on influent flow plus an assumed 50% recycle rate. One hundred per cent return flow capacity was provided. It was assumed that twenty milligrams per liter of ammonia nitrogen would be oxidized in the nitrification process. The nitrification aerator was provided with diffused air equipment with an assumed efficiency of 5%. The theoretical required air was about 0.88 scf/gal. One standard cubic foot of air per gallon of water treated was used for the cost estimate.

The denitrification basin was sized for two hours detention with an excess capacity factor of 1.2. Flocculating equipment was used in the denitrification tank instead of diffused air equipment. Flocculators were sized at one half horsepower per mgd. The cost of the equipment was obtained from the manufacturer and 25% was added for installation. No covers were provided for the denitrification basin. Methanol storage was provided for 30 days of operation with a minimum tank size of 5000 gallons. The cost of storage tanks were obtained from the manufacturer and 50% was added for piping and valves. Using three mg/l of methanol per mg/l of nitrate nitrogen gave a dose of 60 mg/l for methanol. The cost of methanol was obtained from the supplier as 27 cents per gallon, in lots of 5000 gallons or more. One hundred percent recycle capacity was also provided for the denitrification process. A final settler (800 gpd/sq. ft.) was provided.

The wages of non-supervisory workers in water and wastewater treatment was $3.52 per hour in January, 1970. This was increased to $3.75 to provide for supervision. All other cost items such as yardwork which includes interprocess piping, engineering, legal, fiscal, and administrative cost, interest during construction, etc., were taken from the Black and Veatch data.

Cost estimates for nitrification alone were made using the same assumptions and the tables are attached.

PROCESS ELEMENT	DESIGN CRITERION USED
1. Nitrification Tanks	3 hours detention based on influent flow (Excess Capacity Factor = 1.2)
2. Diffused Air Supply for Nitrification	1 scf per gallon treated
3. Nitrification Recycle Pumps	sized for 100% recycle
4. Nitrification Final Settlers	800 gpd/sq ft overflow rate based on influent flow plus 50% recycle
5. Denitrification Tanks	2 hours detention based on influent flow (Excess Capacity Factor = 1.2) (tanks uncovered)
6. Denitrification Agitators	½ horsepower/mgd
7. Denitrification Recycle Pumps	sized for 100% recycle
8. Denitrification Final Settlers	800 gpd/sq ft overflow rate based on influent flow plus 50% recycle
9. Methanol Dose	3 mg/l per mg/l of nitrate nitrogen (60 mg/l)
10. Methanol Storage	30 days supply with a minimum tank size of 500 gallons
11. Methanol Cost	27 cents/gallon

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CAPITAL COST ESTIMATES FOR NITROGEN REMOVAL
BY NITRIFICATION AND DENITRIFICATION
NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	1 mgd	10 mgd	100 mgd
I. NITRIFICATION			
1. Nitrification Tanks	$34,000	$185,000	$1,800,000
2. Diffused Air System	$50,000	$213,000	$1,150,000
3. Recycle Pumps	$31,000	$100,000	$400,000
4. Final Settlers	$45,000	$250,000	$1,400,000
II. DENITRIFICATION			
1. Denitrification Tanks	$28,000	$130,000	$1,200,000
2. Agitators	$12,500	$23,800	$238,000
3. Recycle Pumps	$31,000	$100,000	$400,000
4. Final Settlers	$45,000	$250,000	$1,400,000
5. Methanol Storage	$2,600	$7,000	$30,000
Subtotal	$279,100	$1,258,800	$8,018,000
Yardwork @ 14% of Subtotal	$39,074	$176,232	$1,122,520
TOTAL CONSTRUCTION COST	$318,174	$1,435,032	$9,140,520
Land Required, acres	0.09	0.9	9.0
Land Cost @ $2,000/acre	$180	$1,800	$18,000
Engineering	$63,000	$170,000	$700,000
Subtotal	$381,354	$1,606,832	$9,858,520
Legal, Fiscal, and Administrative	$7,800	$19,000	$50,000
Subtotal	$389,154	$1,625,832	$9,908,520
Interest During Construction	$10,000	$85,000	$800,000
GRAND TOTAL	$401,174	$1,710,832	$10,708,520
LEVEL DEBT SERVICE			
@ 6% and 25 yr. cents/1000 gallons	8.60	3.66	2.30

COST ESTIMATES FOR NITROGEN REMOVAL BY NITRIFICATION AND DENITRIFICATION

DESIGN AVERAGE FLOW = 1.0 mgd NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	Operation mh/yr	Maintenance mh/yr	Total Direct Labor mh/yr	Materials, Supplies, and Utilities $/yr
1. Nitrification Tanks (3 hr)	1,050	510	1,560	7,000
2. Nitrification Recycle Pumps	440	330	770	2,900
3. Nitrification Sedimentation	195	150	345	210
4. Denitrification Tanks (2 hr)	700	340	1,040	1,933
5. Denitrification Recycle Pumps	440	330	770	2,900
6. Denitrification Sedimentation	195	150	345	210
Total Man-hours per Year			4,830	
Total Annual Dollars for Materials, Supplies, and Utilities				$15,163
Total Annual Salaries with 15% Fringe Benefits ($3.75/man-hour)				$20,829
Total Annual Dollars for Salaries and Materials, Supplies, and Utilities				$35,992
Yardwork, Laboratory, and Administrative and General @ 13.2% of Total				$4,751
TOTAL ANNUAL COST FOR OPERATION AND MAINTENANCE				$40,743
OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				11.16
COST OF METHANOL (60 mg/l @ $0.27/gallon), CENTS/1000 GALLONS				2.04
TOTAL OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				13.20

COST ESTIMATES FOR NITROGEN REMOVAL BY NITRIFICATION AND DENITRIFICATION

DESIGN AVERAGE FLOW = 10 mgd NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	Operation mh/yr	Maintenance mh/yr	Total Direct Labor mh/yr	Materials, Supplies, and Utilities $/yr
1. Nitrification Tanks (3 hr)	1,900	1,200	3,100	22,000
2. Nitrification Recycle Pumps	870	620	1,490	5,200
3. Nitrification Sedimentation	1,050	680	1,730	1,020
4. Denitrification Tanks (2 hr)	1,270	800	2,070	3,860
5. Denitrification Recycle Pumps	870	620	1,490	5,200
6. Denitrification Sedimentation	1,050	680	1,730	1,020
Total Man-hours per Year			11,570	
Total Annual Dollars for Materials, Supplies, and Utilities				$38,300
Total Annual Salaries with 15% Fringe Benefits ($3.75/man-hour)				$49,896
Total Annual Dollars for Salaries and Materials, Supplies, and Utilities				$88,196
Yardwork, Laboratory, and Administrative and General @ 13.2% of Total				$11,642
TOTAL ANNUAL COST FOR OPERATION AND MAINTENANCE				$99,838
OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				2.74
COST OF METHANOL (60 mg/l @ $0.27/gallon), CENTS/1000 GALLONS				2.04
TOTAL OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				4.78

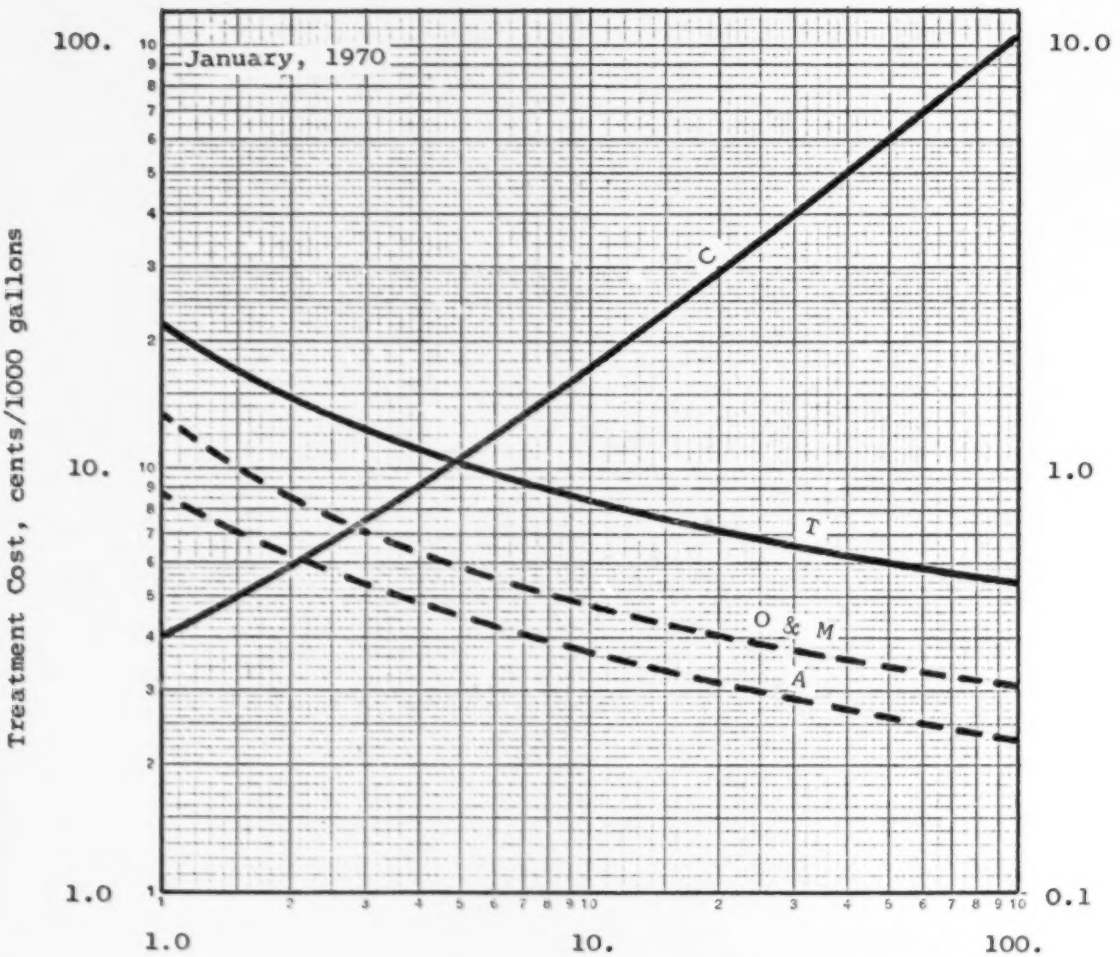
COST ESTIMATES FOR NITROGEN REMOVAL BY NITRIFICATION AND DENITRIFICATION

DESIGN AVERAGE FLOW = 100 mgd NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	Operation mh/yr	Maintenance mh/yr	Total Direct Labor mh/yr	Materials, Supplies and Utilities $/yr
1. Nitrification Tanks (3 hr)	9,200	7,200	16,400	72,000
2. Nitrification Recycle Pumps	1,700	1,200	2,900	9,300
3. Nitrification Sedimentation	6,600	3,400	10,000	5,000
4. Denitrification Tanks (2 hr)	6,133	4,800	10,933	7,650
5. Denitrification Recycle Pumps	1,700	1,200	2,900	9,300
6. Denitrification Sedimentation	6,600	3,400	10,000	5,000
Total Man-hours per Year			53,133	
Total Annual Dollars for Materials, Supplies, and Utilities				$108,250
Total Annual Salaries with 15% Fringe Benefits ($3.75/man-hour)				$229,136
Total Annual Dollars for Salaries and Materials, Supplies, and Utilities				$337,386
Yardwork, Laboratory, and Administrative and General @ 13.2% of Total				$44,535
TOTAL ANNUAL COST FOR OPERATION AND MAINTENANCE				$381,921
OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				1.05
COST OF METHANOL (60 mg/l @ $0.27/gallon), CENTS/1000 GALLONS				2.04
TOTAL OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				3.09

NITRIFICATION AND DENITRIFICATION IN DISPERSED FLOC REACTORS

Capital Cost, Operating & Maintenance Cost, Debt Service
versus
Design Capacity



C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons (6% and 25 yr.)
O & M = Operating and Maintenance Cost, cents per 1000 gallons
T = Total Treatment Cost, cents per 1000 gallons

CAPITAL COST ESTIMATES FOR SEPARATE DISPERSED FLOC SYSTEM
FOR NITRIFICATION DOWNSTREAM OF ACTIVATED SLUDGE PROCESS
NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	1 mgd	10 mgd	100 mgd
1. Nitrification Tanks	$34,000	$185,000	$1,800,000
2. Diffused Air System	$50,000	$213,000	$1,150,000
3. Recycle Pumps	$31,000	$100,000	$400,000
4. Final Settlers	$45,000	$250,000	$1,400,000
Subtotal	$160,000	$748,000	$4,750,000
Yardwork @ 14% of Subtotal	$22,400	$104,720	$665,000
TOTAL CONSTRUCTION COST	$182,400	$852,720	$5,415,000
Land Required, acres	0.06	0.60	6.0
Land Cost @ $2000/acre	$120	$1,200	$12,000
Engineering	$28,000	$130,000	$480,000
Subtotal	$210,520	$983,920	$5,907,000
Legal, Fiscal and Administrative	$5,300	$18,000	$38,000
Subtotal	$215,820	$1,001,920	$5,945,000
Interest During Construction	$5,500	$45,000	$410,000
GRAND TOTAL	$221,320	$1,046,920	$6,355,000
LEVEL DEBT SERVICE			
@ 6% and 25 yr. cents/1000 gallons	4.74	2.24	1.36

OPERATION AND MAINTENANCE COST ESTIMATES FOR A SEPARATE DISPERSED FLOC SYSTEM FOR NITRIFICATION DOWNSTREAM OF THE ACTIVATED SLUDGE PROCESS

DESIGN AVERAGE FLOW = 1.0 mgd NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	Operation mh/yr	Maintenance mh/yr	Total Direct Labor mh/yr	Materials, Supplies, and Utilities $/yr
1. Nitrification Tanks (3 hr)	1,050	510	1,560	7,000
2. Nitrification Recycle Pumps	440	330	770	2,900
3. Nitrification Sedimentation	195	150	345	210
Total Man-hours per Year			2,675	
Total Annual Dollars for Materials, Supplies, and Utilities				$10,110
Total Annual Salaries with 15% Fringe Benefits ($3.75/man-hr)				$11,536
Total Annual Dollars for Salaries and Materials, Supplies, and Utilities				$21,646
Yardwork, Laboratory, and Administrative and General @ 13.2% of Total				$2,857
TOTAL ANNUAL COST FOR OPERATION AND MAINTENANCE				$24,503
TOTAL OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				6.71

OPERATION AND MAINTENANCE COST ESTIMATES FOR A SEPARATE DISPERSED FLOC SYSTEM FOR NITRIFICATION DOWNSTREAM OF THE ACTIVATED SLUDGE PROCESS

DESIGN AVERAGE FLOW = 10 mgd NATIONAL AVERAGE COST, January, 1970

PROCESS COMPONENTS	Operation mh/hr	Maintenance mh/yr	Total Direct Labor mh/yr	Materials, Supplies and Utilities $/yr
1. Nitrification Tanks (3 hr)	1,900	1,200	3,100	22,000
2. Nitrification Recycle Pumps	870	620	1,490	5,200
3. Nitrification Sedimentation	1,050	680	1,730	1,020
Total Man-hours per Year			6,320	
Total Annual Dollars for Materials, Supplies, and Utilities				$28,220
Total Annual Salaries with 15% Fringe Benefits ($3.75/man-hr)				$27,255
Total Annual Dollars for Salaries and Materials, Supplies, and Utilities				$55,475
Yardwork, Laboratory, and Administrative and General @ 13.2% of Total				$7,323
TOTAL ANNUAL COST FOR OPERATION AND MAINTENANCE				$62,798
TOTAL OPERATION AND MAINTENANCE COST, CENTS/1000 GALLONS				1.72